



US006593677B2

(12) **United States Patent**
Behin et al.

(10) **Patent No.:** **US 6,593,677 B2**
(45) **Date of Patent:** ***Jul. 15, 2003**

(54) **BIASED ROTATABLE COMBDRIVE
DEVICES AND METHODS**

(75) Inventors: **Behrang Behin**, Berkeley, CA (US);
Satinderpall Pannu, Berkeley, CA
(US)

(73) Assignee: **Onix Microsystems, Inc.**, Fremont, CA
(US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 97 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **09/810,336**

(22) Filed: **Mar. 14, 2001**

(65) **Prior Publication Data**

US 2001/0050801 A1 Dec. 13, 2001

Related U.S. Application Data

(60) Provisional application No. 60/191,856, filed on Mar. 24,
2000.

(51) **Int. Cl.**⁷ **H02N 1/00**; G02B 26/08;
G02B 26/10

(52) **U.S. Cl.** **310/309**; 359/224; 359/290;
73/504.12; 324/661

(58) **Field of Search** 310/309; 318/116;
359/223, 324, 298, 872, 877, 290, 291;
73/504.12, 504.14, 504.02, 514.16, 514.29;
324/661, 662, 658, 679, 207.11, 207.14;
251/129.01

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,317,611 A 3/1982 Petersen 350/6.6

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

DE 296118818 12/1996 G02B/6/35

(List continued on next page.)

OTHER PUBLICATIONS

"Electrostatic Comb Drive For Vertical Actuation" A.P. Lee
et al., Proceedings of the SPIE, SPIE, Bellingham, VA, vol.
3224, Sep. 29, 1997, pp 109-119.

(List continued on next page.)

Primary Examiner—Karl Tamai

(74) *Attorney, Agent, or Firm*—JDI Patent; Joshua D.
Isenberg

(57) **ABSTRACT**

Rotating devices including actuators and position sensors that employ combdrives are described. One design of a combdrive fabricated from a single layer is provided such that, in a nominal state, the two sets of comb fingers are substantially interdigitated according to a predetermined engagement. A rotating element may be attached to a rotatable flexure disposed along an axis and coupled to the comb fingers along with a biasing element attached to the rotating element to cause the comb fingers along with the rotating element to undergo a controlled angular displacement from the initial engagement and in response to feedback from sensing the position of the movable or rotating element. A voltage may be applied between comb fingers to cause the rotating element to undergo further rotation about the axis in a predetermined manner. Alternatively, a time-vary biasing force may be exerted on the rotating element, causing the first comb fingers along with the rotating element to undergo further rotation about the axis in a predetermined manner. The combdriven device can serve as both rotating actuators and position sensor. By arranging two such combdrives in a gimbaled structure bi-axial rotating actuators and position sensors may be constructed. The combdrive devices of the present invention can be employed in a broad range of applications, including biomedical devices, optical devices for tracking and display, telecommunication devices such as fiber-optic switches, inertial sensors, and magnetic disk drives.

60 Claims, 8 Drawing Sheets

